

PixelVision, Inc.

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SPECTRAVIDEO™ CAMERA USER'S MANUAL

DOCUMENT CHANGE NOTICE				
REV	DATE	DCN	ORIGINATOR	SUMMARY OF CHANGES
A	2/8/98	n/a	T. Nebeker	Original Document
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C	2/15/00	n/a	T. Nebeker	Updates/Edits



**SPECTRAVIDEO™ CAMERA
USER'S MANUAL**

LIMITED WARRANTY

PixelVision of Oregon, Inc. warrants that The SpectraVideo™ series of cameras (the “camera”) will perform essentially in accordance with the accompanying documentation for a period of one (1) year from date of receipt. If there are physical defects in workmanship or materials in the camera or documentation that are not associated with normal use and service, PixelVision, Inc. will replace or repair camera or documentation free of charge within the period of one (1) year from the date of receipt. The limited warranty is void if failure of the camera has resulted from accident, abuse or misapplication on the part of the user.

If the camera must be returned to PixelVision, Inc. for replacement or repair, it must be packed in its original material, as it was shipped to you. The limited warranty may be voided if the camera is not returned in its original packing material.

Some states do not allow exclusions or limitations of implied warranties, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights and you may also have other rights that vary from state to state.

DAMAGE DISCLAIMER

At no time will PixelVision, Inc. be liable for direct, indirect, incidental or consequential damage to hardware or software, loss of business profits, loss of clients (potential and existing) or loss of information arising from the use or inability to use the SpectraVideo™ series cameras, PixelView™ software program or pertaining documentation. PixelVision, Inc. has no liability for any data stored or processed with this software, including any costs for recovery of such data.

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1. INTRODUCTION



The SpectraVideo™ series of high performance, charge-coupled device (CCD) cameras, manufactured by PixelVision, Inc., offer excellent sensitivity and low noise throughout the visible and ultra-violet spectral regions. The affordable SpectraVideo series cameras use Scientific Imaging Technologies, Inc. (SITe)-designed CCDs. The camera's back-illuminated CCD detector has as high as ninety-nine percent quantum efficiency in the visible spectral region.

An optional ultra-violet, anti-reflective coating allows for excellent sensitivity throughout the visible and ultra-violet spectral regions.

Thinned, back-illuminated CCDs overcome the performance limits of the conventional front-illuminated CCDs by illuminating and collecting charge through the back surface away from the polysilicon gate electrodes on the front surface. The image photons enter the CCD back surface unobstructed, allowing for high quantum efficiency visible and ultra-violet light detection. Software gain and shutter control allow variable exposure, binning, region of interest (ROI) and timing.

The camera is delivered with a head assembly, camera control box, data acquisition board and PixelView™ (PixelVision, Inc.'s easy-to-use Microsoft Windows®-based software package). The head assembly and camera control box provide all of the necessary circuitry to operate the CCD array and provide low noise signals to the computer interface. A LynxPCI™ data acquisition board acquires the images. The detector head is adaptable to most popular lens mounts, with an 'F' mount standard. Exposure, temperature, gain and pixel binning are controlled using PixelView.

2. GENERAL DESCRIPTION OF CAMERA

The SpectraVideo series camera is a two-piece camera design. A schematic representation of the camera is shown in Figure 1. The CCD, thermoelectric cooler, and pre-amplifier are all contained in the head assembly. The amplified output of the CCD is transmitted over coaxial cable to the SpectraVideo camera control box.

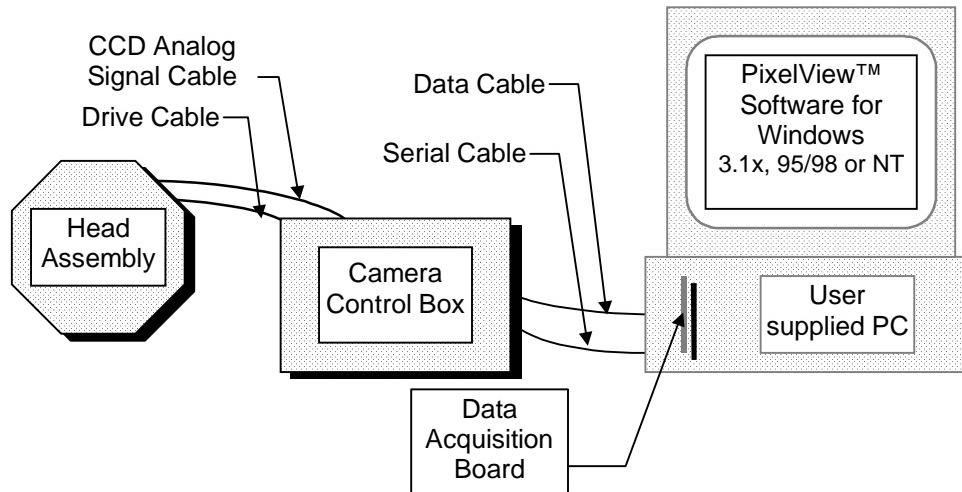


Figure 1 Schematic Representation of the SpectraVideo camera electronics

The CCD clock and bias signals are provided to the head from the camera control box through the drive cable. The pre-amplified CCD signal is returned through the CCD analog signal cable. The camera control box houses: 1) the power supplies necessary to operate the camera and thermoelectric cooler; 2) the digital control board that generates the clocking to operate the CCD; 3) the analog signal processing board; and 4) the shutter and cooler control board. On those cameras using a PCI bus data acquisition card and fiber optic data link, a serial to parallel converter board is also contained in the camera control box.

The digital control board contains the sequencer which generates the logic signals for all time critical tasks associated with the CCD readout, the drivers which clock the CCD gates, and the bias supplies for the driver rails. The sequencer is a programmable digital signal processor (DSP) and many timing parameters are controlled through its serial port. The analog signal processing board contains the correlated double sampled (CDS) analog signal chain, the 16 bit, analog-to-digital converter (ADC) and optical isolation from the PC to improve noise immunity.

2.1. DIGITAL DATA ACQUISITION BOARD

SpectraVideo cameras are shipped with a 16 bit digital input interface to a LynxPCI data acquisition board that acquires the images. The data acquisition board receives digital signals from the SpectraVideo camera and the PixelView software program captures the data that corresponds to the image's pixel intensity values and places the image into the PC memory, pixel-by-pixel. For more detailed information on the data acquisition board, see Section 1.

2.2. PIXELVIEW SOFTWARE

PixelView software is provided with every SpectraVideo camera. PixelView is an easy-to-use Windows-based image acquisition and analysis software package that supports the features of the SpectraVideo camera. The software also includes many intuitive image processing and analysis tools. Through the data acquisition board, PixelView captures the 16 bit data that corresponds to the image's pixel intensity values and places the image into the PC memory, pixel-by-pixel.

PixelView has an intuitive structure where images and graphics are associated with windows. The Shortcut Key feature (a combination of mouse drags and key pushes) makes graphics and analysis just a touch away. Some of the most commonly used analysis and display tools are accessible from toolbox buttons. The pull down menu system is user friendly and easy to learn.

For detailed information on the functions of the PixelView software program, please refer to the *PixelView Software User's Manual*.

2.3. SOFTWARE DEVELOPER'S KIT

PixelView uses device drivers that are loaded at system boot. These drivers can also be accessed from the user's software through provided DLLs.

2.4. SYSTEM REQUIREMENTS

The recommended hardware system to run your SpectraVideo camera is a 233 MHz Pentium processor with at least 64 MB of RAM and 5 MB of available disk space.

PixelView is compatible with Windows 95/98/NT. It is not compatible with earlier versions of Window. The program also requires a display adapter that supports at least 256-color displays.

PixelView supports 1-, 2-, or 4-channel versions of the LynxPCI data acquisition board with either a parallel or fiber optic interface. In addition, PixelView supports controlling a single camera using two LynxPCI cards, but does not support controlling multiple cameras with multiple boards.

The camera determines the data acquisition rate and you must ensure that your computer has sufficient resources to keep up with the rate at which the camera transmits data. Computers operating with higher clock speeds will not acquire images faster than the rate determined by the camera; however, as bus and microprocessor clock speeds improve the efficiency in which the computer handles background tasks, a faster computer increases the reliability of acquiring images.

PixelView does not interface directly with any other program; however, the software reads and writes files that can be shared with other programs. PixelView uses TIFF as its default file format.

3. SPECTRAVIDEO CAMERA SETUP

3.1. PRECAUTIONS



CAUTION! Charge-Coupled Devices (CCDs) are extremely sensitive to electrostatic discharge (ESD) damage. The CCD may be damaged by discharges of as low as 50 Volts. Do not unplug the head assembly unless at an ESD safe workstation.

Your camera may have been shipped with the Head Assembly separate from the camera control box. If so, the Head Assembly will have a shorting bar on its 37-pin connector. Do not remove the shorting bar unless at an ESD safe workstation. Connect the Head Cable to the camera control box. Remove the shorting bar and replace it with the Head Cable. Be sure the Head Cable connectors are screwed in at both ends.

The computer +5 Volt supply is available on pin 37 of the D37 connector of parallel data acquisition board. It is highly recommended that the computer be turned off when connecting the data cable on these cameras. The PCI data acquisition board has a fuse on this supply voltage pin. A damaged fuse on a PCI board can cause a serial port command upload failure error message.

Please save all packing material! If the camera must be returned to PixelVision, Inc. for replacement or repair, it must be packed in its original material, as it was shipped to you. The limited warranty may be voided if the camera is not returned in its original packing material. If you need new packing material, please contact PixelVision, Inc.

3.2. SETUP

Your SpectraVideo camera is shipped prepared for easy integration and operation. Included in your shipment is a Packing List. Please verify that all parts have been received. If any parts listed in the Packing List are not received with this package, please contact PixelVision, Inc. Immediately.

Start by plugging the power cord into the power supply box then into a grounded power source (a grounded wall socket is preferred). **Leave the camera and computer off until all the cabling is connected.**



CAUTION! The camera is shipped with the drive cable from the camera control box to the head assembly connected. **DO NOT REMOVE THIS CABLE.** Removal will expose the static-sensitive CCD to possible electrostatic discharge (ESD) damage.

For the camera control box to communicate with your PC, the data acquisition board must be installed, if there is not one already installed. To install the board:

1. Make sure the computer is turned off.
2. Leave your computer plugged into a grounded power source, if it is not already plugged in (a grounded wall socket is preferred).
3. Remove the computer's chassis cover and locate a free PCI expansion slot.
4. Remove the protective plate covering that corresponds to the chassis slot, saving the machine screw.
5. Dissipate any static electricity by touching a bare-metal portion of the PC chassis.
6. Remove the data acquisition card from the anti-static bag, holding the board's edge (**do not touch the board's back or the connectors because these areas are more susceptible to retained static charge**).
7. Insert data acquisition board into the free PCI expansion slot, making sure that the board is fully seated.
8. Secure the board bracket using the machine screw from the chassis slot plate.
9. Replace the chassis cover.

If you are not using a PCI bus data acquisition board with fiber optic links, you must connect the 9-pin serial data cable from the port on the back of the camera control box marked "serial control" to a free serial (COM) port on your PC. Note which serial (COM) port you are using for setup of PixelView. Then connect the parallel cable from the port marked "Parallel Data" to the parallel port on the data acquisition card. Figure 2 shows the camera setup with serial/parallel cabling. If you are using a fiber optic link, install the fiber optic cables from the data acquisition board to the camera control box.



CAUTION! When inserting or detaching the fiber optic cables, grasp the metal nut at the end of the cable. Do not push or pull on the cable itself. When removing the plastic cover at the tip of the cable, grasp the metal nut, not the cable. DO NOT tie the fiber optic cable in a knot. Bending the cable in a circle with a radius smaller than four inches can damage the cable.

To connect the fiber optic cables:

1. Remove the fiber optic port plugs by turning counter-clockwise $\frac{1}{4}$ turn and then pulling out.
2. The first fiber optic cable goes from the port labeled "FO1" on the back of the camera control box to the **top** fiber optic port on the data acquisition board. The "top" port is the port farthest away from where the board is plugged into the extension slot. Remember to loosen or tighten the cable using the metal nut. Do not push or pull the cable itself. Rotate the metal nut clockwise until the key slot drops into place.

3. The next cable goes from the port labeled “FO2” on the back of camera control box to the next available port on the data acquisition board (again, in order from top to bottom on the board).



NOTE: If the camera control box has more than two fiber optic ports, continue to use the next available port on the data acquisition board for each cable coming from the camera control box, in order from top to bottom on the board.

Once the cables are connected, restart your computer. If you are running PixelView and a LynxPCI data acquisition board, when you restart your computer, Windows 95 should inform you that it has detected new hardware, and ask you for a driver disk for this hardware. Insert the disk label “PCI Driver Disk” into your 3½” floppy drive, select that drive, and click “OK.” Follow any instructions Windows 95 presents. Some PC systems may prompt you for a file name or directory in the Copy files from: box. If this occurs, type the correct path to your floppy drive (i.e. ‘a:’) and press enter. You may have to direct the search to your floppy drive more than once on some systems, especially if your system has a CD-ROM drive.

For “internal exposure” use the short coaxial “exposure control loop back” cable provided to connect the “Exposure Out” connector on the back of the camera control box to the “Exposure In” connector (see Figure 2). For external exposure, disconnect this cable and provide a TTL gate to the “Exposure In” connector (see Section 4.1 for detailed information). In internal exposure, the camera controls the exposure start and exposure duration; but, while in external exposure mode, exposure is slaved to the gate pulse provided by the user.

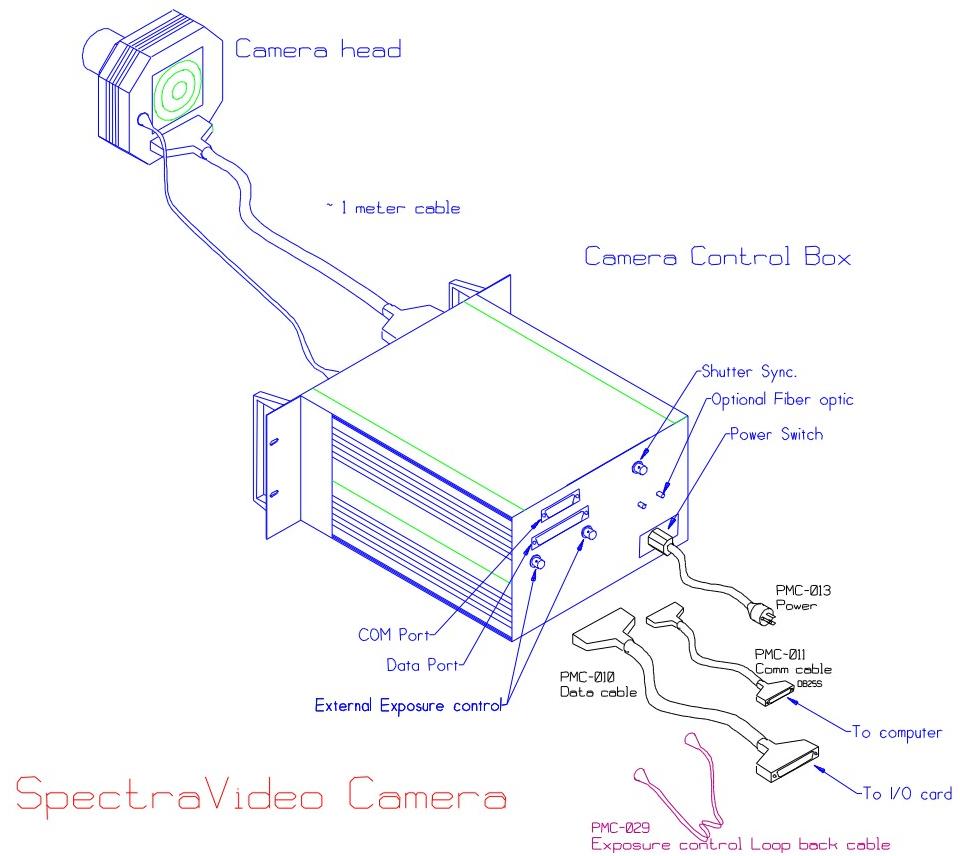


Figure 2 SpectraVideo Camera with Serial/Parallel Cable Interface

The camera head is provided with a Nikon lens mount standard. A C-mount or Canon lens mount is optional. A ¼ inch – 20 tpi mounting hole is provided in the camera head.

For specific information on the installation of the PixelView software program, please refer to the *PixelView Software User's Manual*.

3.3. SPECTRAVIDEO FAMILY GENERAL SPECIFICATIONS

Below are the general specifications for the SpectraVideo family.

Full Well Capacity	80,000 – 1,200,000 e ⁻
Readout Amplifier Noise	4 - 9 e ⁻ /per readout @ -45°C., 50kpix/sec
A/D Conversion	16 bit
Readout Rate	50 - 450 kpix/sec (1 Mpix/sec optional)
Shutter	DC to 50 milliseconds, software or external sync control
Row Shift Period	24 – 60 µsec
Gain Settings	Software select, High (app. 4.5 e ⁻ /ADU) or Low (app. 9 e ⁻ /ADU)
Binning and Region-of-Interest (ROI)	Binning and ROI is software selectable in X and Y coordinates
Cooling Capacity	2-stage TE Vacuum Module -45 – -60°C from ambient 3-stage TE O-ring Dewar -70°C from ambient
Electrical Input	100 VAC - 240 VAC 50 - 60Hz
Computer Interface	Serial port and PCI bus (fiber optic cabling available with PCI bus)
Camera Head Dimensions	4.0"(w) x 4.0"(h)
Operating Mode	Software selectable via serial port or fiber optic link
Recommended Computer System Requirements	233MHz Pentium processor with at least 64 MB of RAM and 5MB of available disk space
Software	PixelView is provided with each camera

Table 1 SpectraVideo Family General Specifications

4. CAMERA EXPOSURE CONTROL

4.1. EXTERNAL EXPOSURE CONTROL

Exposure may be controlled externally by supplying a TTL level to the “Exposure In” connector on the back of the camera control box, with “Exposure Out” disconnected. The TTL level is normally high; exposure will occur while the level is pulled low. With a brief delay (typically 15 μ s), as soon as the level goes low, the camera will go into exposure mode and communication with the camera will be suspended until exposure is discontinued and a frame readout is complete.

If you are running PixelView, exposure must be set to Externally Gated in the Exposure Tab within the “Camera Setup” dialog box under the Control menu.

A new frame must then be acquired. The software will wait until an exposure has occurred and will capture the frame. Pressing the Escape key will cancel the acquisition. Once a single frame has been acquired, selecting the **Continuous** (Ctrl-C) item from the **Acquire** menu makes continuous acquisitions.

The entrance into exposure mode may be delayed for as long as it takes the parallel gate drivers to fall, typically 15 μ s. Consequently, the exposure gate should precede the external event by at least 15 μ s.

After the exposure gate rises, the CCD will continue to expose to allow time for a shutter to close, phosphor to decay, etc. The length of time is determined by the value entered in the “After Exposure” box within the Rate Tab of the “Camera Setup” dialog box under the Control menu. After exposure wait can also be accessed by the user’s software. Figure 3 below shows the relationships between the various waveforms.

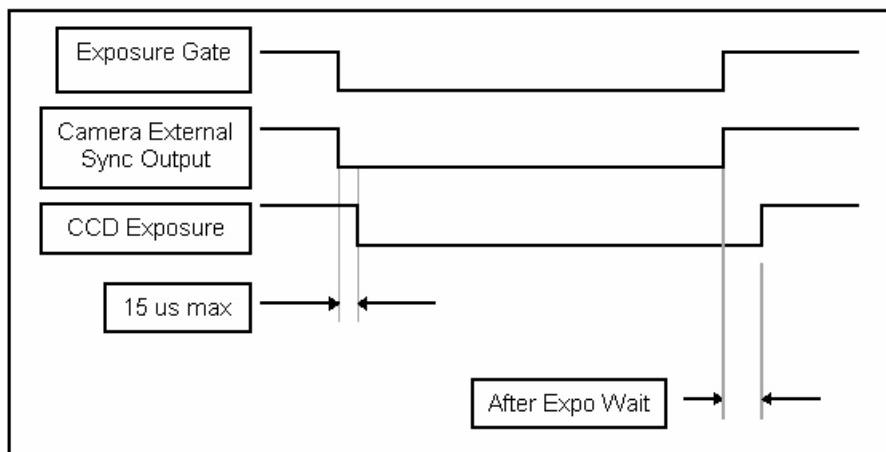


Figure 3 Exposure Timing Relationships

When using an external exposure gate, the beginning of exposure will not be synchronized with the end of a CCD line and there will be a slight difference in dark current between two frames with the same exposure. This results from the dark current accumulated during the uncertainty in one line. This effect should be small for cooled CCDs running at high speeds.

When externally gated exposure mode is selected, the Digital Signal Processor (DSP) stops the parallel gates for the duration of the low level on the exposure gate ($\pm \frac{1}{2}$ row readout + one parallel shift).



NOTE: When using a PCI data acquisition board, the 100 μ s signal is the signal that is generated by the PCI board. The signal goes to the DSP that controls CCD shifting. This DSP acts on the falling edge.

4.2. SOFTWARE TRIGGERED EXPOSURE CONTROL

To use software triggered exposure control, the connector on the camera control box labeled “Exposure Out” must be looped back to the connector labeled “Exposure In.” A short coaxial cable is provided with each camera for this use. If PixelView used, exposure must be set to Software Trigger in the Exposure Tab within the “Camera Setup” dialog box under the **Control** menu.

Internal exposure timing is handled by the DSP and when a new frame is requested, the camera will complete clearing the serial register before beginning the exposure. A TTL level that is low while the camera is exposing is available at the Sync connector on the front panel of the camera control box.

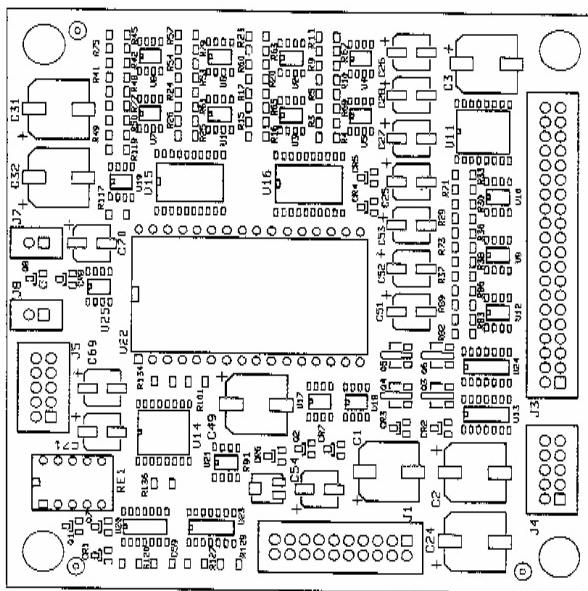
Internal exposure duration may be set from 25 μ s to over 100 hours with a granularity of 100 ns or 62.5 ns, depending on the frequency of the system clock.

When externally triggered exposure mode is selected, the DSP stops the CCD parallel gates for the programmed exposure time, starting on the falling edge of the Exposure In signal.

5. ANALOG SIGNAL PROCESSING BOARD

5.1. OVERVIEW

The analog signal processing board is used to amplify the output signal from the CCD and digitize it. The analog processing board contains the clamp/sample correlated double sample circuit, the analog signal chain, the analog-to-digital converter, and the optical isolation circuitry that provides noise immunity from the PC.



upper end of the dynamic range is set to the full well potential of the CCD's parallel pixel charge sites and so that 2 bits are used to sample the noise floor of the camera. The LOW gain setting is used to match the upper end of the ADC's dynamic range to the full well potential of the CCD's serial pixels. Under typical operating conditions, gain setting is performed by the PixelView software package.



NOTE: If you are running a two-speed camera, the HIGH gain setting is used for high speed operation, and the LOW gain is used for low speed operation.

5.2.2. ANALOG OUTPUT

Buffered analog output (0 to -10V range) taken just prior to input to the analog to digital converter is available on J7 outer most pin. DC offset may be adjusted on R11 of the clamp sample piggyback board.

J7 pin 2	J7 pin 2
Analog output	GND

Table 2 Analog Output on the PMB-003

J5 pin	Function	J5 pin	Function
1	-15V	2	Last Gate
3	GND	4	Vrd
5	GND	6	Vdd
7	+15V	8	GND
9	GND	10	Analog Signal

Table 3 Low Noise Cable Connection to Socket Board

5.2.3. BOARD TO BOARD SIGNAL CONNECTIONS

Control signals from the DSP digital board control. Analog signal processing for noise reduction and data conversion.

J1 pin	Function	J1 pin	Function
1	-15Vdc	2	~Sample/Hold 1
3	GND	4	~Start Convert
5	+5Vdc	6	~Output Enable
7	+15Vdc	8	~Sample/Hold2
9	GND	10	Expo_Gate
11	GND	12	Gain
13	GND	14	Serdatain
15	GND	16	Serdataout
17	GND	18	Frame blank
19	serclk	20	Line blank

Table 4 Analog Board to Digital Board Control Cable Connections

5.2.4. DIGITAL INPUT/OUTPUT

J3 pin	Function	J3 pin	Function (with Serial I/O)
1	Data 0 (LSB)	2	n/c
3	Data 1	4	n/c
5	Data 2	6	PC GND
7	Data 3	8	Line Blanking pulse
9	GND	10	Frame Blanking pulse
11	Data 4	12	~ Output enable 0
13	Data 5	14	PC GND
15	Data 6	16	~ Output enable 1
17	Data 7	18	n/c
19	GND	20	Data Valid strobe
21	Data 8	22	~ Output enable 2
23	Data 9	24	PC GND
25	Data 10	26	~ Output enable 3
27	Data 11	28	n/c
29	GND	30	n/c
31	Data 12	32	n/c
33	Data 13	34	n/c
35	Data 14	36	+5V from PC
37	Data 15 (MSB)	38	TTL in
39	Serial clock	40	TTL out

Table 5 PMB-003 Data I/O Connector

5.2.5. RS232 INPUT

RS232 control of DSP parameters is accessible through the RS232 connector. This connector can be connected straight across to a DB9 connector. These RS232 connections also appear in the data I/O connector (J3) for convenience. Parallel SpectraVideo cameras use an RS232 port. CommTest is a program used to exercise the serial port of the Imaging Module in order to determine the health of the link. For more information on the CommTest program see Section 12.1.

J4 pin	Function	J4 pin	Function
1	NC	2	nc
3	RS232 input	4	nc
5	RS232 output	6	nc
7	NC	8	nc
9	GND	10	nc

Table 6 PMB-003 RS232 Connector

6. DIGITAL CONTROL BOARD

6.1. OVERVIEW

The SpectraVideo digital control board generates the clock signals used to operate the CCD. High performance clock drivers generate the clock signals. A digital signal processor (DSP) controls the clock waveforms. Using a DSP allows users flexibility in operating and optimizing the CCD. Readout rates, pixel binning, and region of interest readout are all easily modified using the DSP.

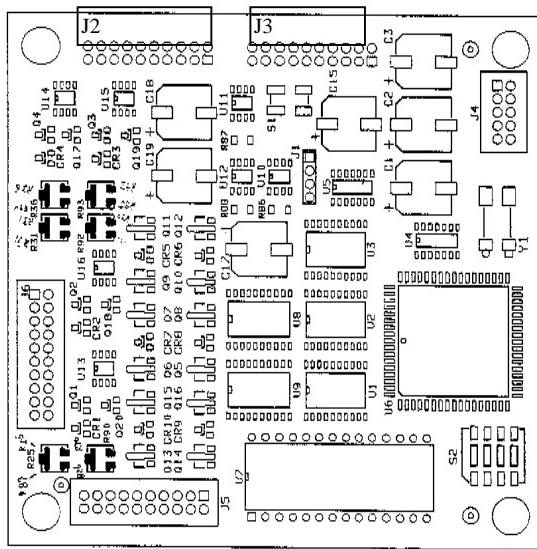


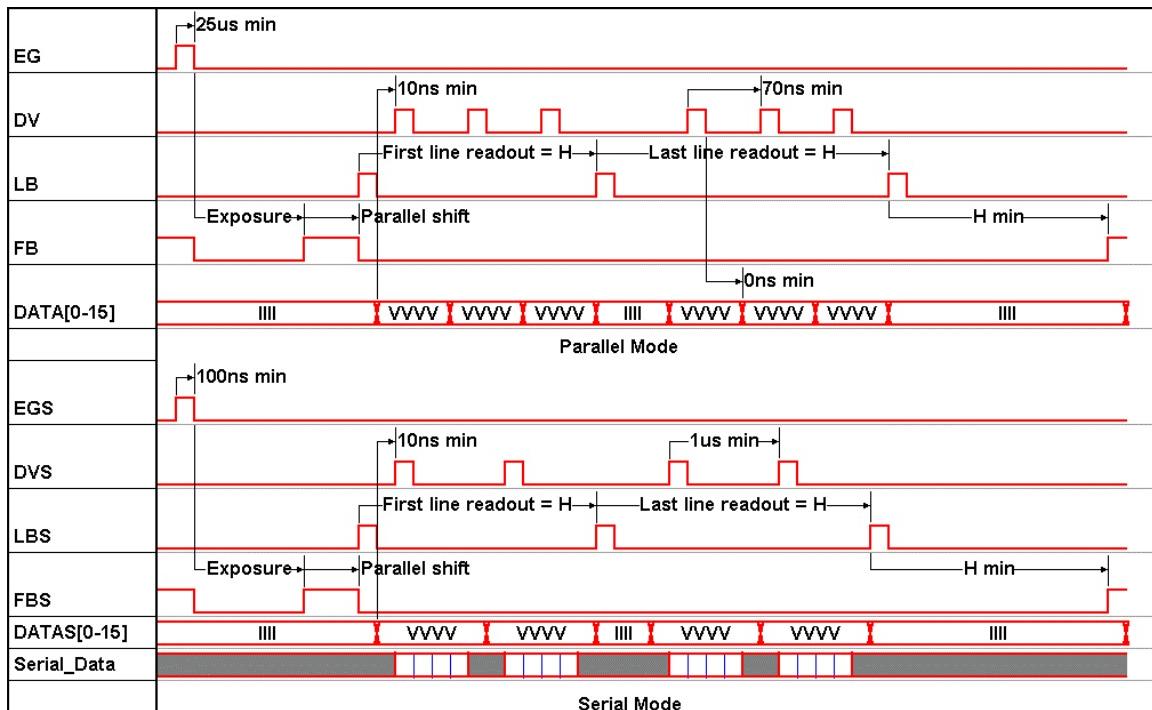
Figure 5 SpectraVideo Digital Control Board Layout

6.2. TIMING SEQUENCE

The DSP program has four basic modes: flush, exposure, after exposure and readout. During the flush mode the CCD is cleared as quickly as possible and the data is not transferred to the PC. Exposure mode is entered from the flush mode. During the exposure interval the CCD central array is not shifted to avoid blurring of the image. An after exposure delay can be set through the serial port to allow time for the shutter to close or a phosphor to decay before readout. The readout mode is entered from the after exposure mode. During readout the charge in the CCD pixels is clocked out, amplified, processed and digitized. A Data Valid strobe is active for those pixels that will be transferred to the computer. If region of interest readout is active, only the data from the region will have Data Valid strobes.

An Exposure Gate pulse of 25 μ s minimum width must be provided to this board to trigger exposure as discussed below.

A Line Blank and Frame Blank pulse are provided in addition to the Data Valid strobe. The Line Blanking pulse is high for the parallel shifts. Line Blanking is only active with a Region of Interest (ROI) selected. Frame Blanking is low during the exposure period, high during the after exposure delay and then low during the readout. In this way the I/O channel to the PC can sense the internal exposure gate timing.



EG=Exposure Gate

DV=Data Valid

LB=Line Blanking

FB=Frame Blanking

Figure 6 Camera Control Timing for Internal Exposure Mode



NOTE: For external exposure mode, EG must be high the entire exposure period. Parallel mode is used with the parallel data input option and serial mode is used with the serial fiber optic input option.

6.2.1. FLUSH MODE

After readout or after rebooting the DSP, the CCD is kept flushed of charge indefinitely by a parallel transfer, serial readout sequence. The only way to get out of this mode is to trigger an exposure.

6.2.2. EXPOSURE MODE

CCD exposure is controlled by a user provided external gate (input through the digital I/O connector on PMB-003). Internal or External exposure timing may be selected through the serial port as explained under the software development section. Exposure begins on the falling edge of the exposure gate. The exposure gate should stay low or high for a minimum of 25 μ s. For internal exposure mode the DSP handles the exposure duration after an exposure is triggered. For external exposure mode, the exposure gate must be held low through the entire exposure.

6.2.3. AFTER EXPOSURE MODE

After the exposure has finished, the DSP will keep the CCD in exposure mode longer to allow time for a shutter to close, phosphor to decay, etc. The after exposure wait can be set through the serial port.

6.2.4. READOUT MODE

After every exposure, a CCD readout occurs with the data valid strobe active. The readout may not be interrupted, except by DSP reset.

The rising edge of the data valid strobe occurs after valid data appears on the data bus. There is a pipeline delay of 3 pixels. The first three pixels after a parallel shift are discarded by the warm-up sequence because the first two were in the pipeline during the shift plus the third is slewing back to baseline conditions. The data valid pulse is blanked except for unblanked pixels.

6.2.5. CLOCKING PARAMETERS

The serial port may be used to change several counters used in the DSP program as well as to control the exposure and readout modes. See Section 1 on software development for details.

6.2.6. DIGITAL CONTROL BOARD CONNECTIONS

6.2.6.1. Scope Triggers

Pixel, line and frame triggers are available. Pixel clock is high for the reset gate period of the serial pixel shift sequence, line clock is high during parallel shift and shutter is high during exposure.

J1 pin #	Function
1	GND
2	Pixel clock (reset gate logic)
3	Line clock (parallel shift period)
4	Shutter

Table 7 PMB-001 Scope Trigger Outputs

6.2.6.2. Control Input/Output

Power and shutter logic (high during exposure) are available for use by other equipment. ~DSP reset is a logic input which causes the DSP to boot from PROM page 0 when pulled low and released. Aux data is an 8 bit word that may be written by the DSP with accompanying CLK and write signals. This port is used by the Aux board for temperature control and by the Jaguar serial interface board for receipt of channel enable pulses.

J2 Pin #	Function	J2 Pin #	Function
1	-15V	2	~DSP reset
3	GND	4	Shutter
5	+5V	6	Aux dat 1
7	+15V	8	Aux dat 2
9	GND	10	Aux dat 3
11	GND	12	Aux dat 4
13	GND	14	Aux dat 5
15	GND	16	Aux dat 6
17	Clockout	18	Aux dat 7
19	Aux1_write	20	Aux dat 8

Table 8 Control Input/Output on PMB-001 Analog to Digital Board Connections

6.2.6.3. Analog to Digital Board Connections

The digital DSP board controls the digitization and analog signal processing through a board to board ribbon cable.

J3 pin #	Function	J3 pin #	Function
1	-15Vdc	2	~SH1
3	GND	4	~SC
5	+5Vdc	6	~OE
7	+15Vdc	8	~SH2
9	GND	10	Expo_Gate
11	GND	12	Gain
13	GND	14	Serdatain
15	GND	16	Serdataout
17	GND	18	~frmvalid
19	serclk	20	~linvalid

Table 9 Digital to Analog Board Control Cable Connections

6.2.6.4. Socket Board Signals

The digital DSP board contains the gate drivers used to clock the CCD. The drive signals are sent to the socket board.

J6 Pin #	Function	J6 Pin #	Function
1	GND	2	SWout
3	GND	4	S1out
5	GND	6	S2out
7	GND	8	S3out
9	GND	10	~Reset Logic
11	GND	12	P1out
13	GND	14	P2out
15	GND	16	P3out
17	GND	18	Tgout
19	Reset gate High rail voltage	20	TGbias

Table 10 Socket Board Connector on PMB-001

On PMB-001AC circuit boards, pin 19 is a reset gate dc voltage level and pin 10, Rsout, is the TTL reset circuit signal contained on the socket card.

7. SERIAL INTERFACE BOARD

The Serial Interface Board provides a serial interface to the PCI-based data acquisition card. The card is located in the camera control box and has a standard form-factor of 4" x 4". In both serial modes up to 4 channels can be multiplexed in the same serial line at speeds of ≤ 454 kpix.

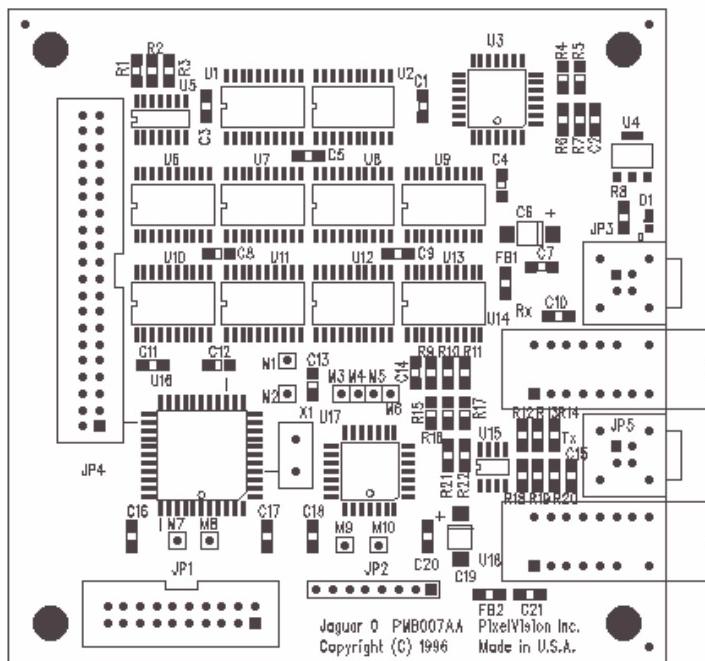


Figure 7 PMB-007 Serial Interface Board Layout

The card employs a Lattice ispLSI-2032 In-System programmable PLD as a service controller. It provides:

- 4-channel serial transmitter control
- clock divider
- violation control

A “transparent” AMD TAXI transmitter Am7968 and a receiver Am7969 are used in the serial link between the PMB-007 and the PCI bus data acquisition board. They are able to send, asynchronously via differential PECL lines, 8 bit data and 3 bit commands providing auto-synchronization and error checking. Receivers on the host interface side can be configured such that only one link with time-multiplexed data from 4 outputs can be used, providing 16Kx16K total resolution.

Although the link is error-free, every 8 bit word in the RS232 emulation stream is checked for errors and should they happen, a violation flag will be raised and an on-board LED will be lit.

Up to four Analog boards can be used to provide an input signal to the board. They all share the same 16 bit bus. Additional write enable signals are provided by the Digital Control Board to latch every channel in its own latch to read later by the controller. The card provides loop back of these 4 enable signals to the Analog Signal Processing Board.

Software for RS232 serial emulation and board status mailbox message handling is provided in PVLYNXX.DLL.

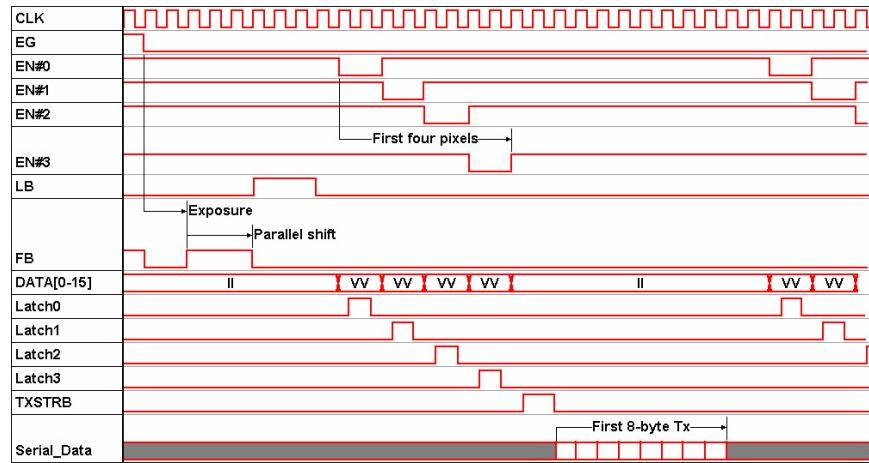


Figure 8 Serial Interface Board Timing

8. SHUTTER AND COOLING CONTROL BOARD

The shutter and cooler control board provides the drive circuitry to control the shutter as well as temperature control for the thermoelectric cooler (TEC) and CCD. The shutter supply circuit operates from the +15V power supply to make +70V for the shutter. During exposures, closing a switch between the supply and the shutter opens the shutter. Immediately after exposure, the shutter supply recharges. The Camera External Sync output is low during the time the shutter is open and +5V otherwise.

PixelView uses two constants called TempGain and TempOffset. These values are used to convert a temperature to a binary value to send after the ‘x’ command:

$$x = 256 * \frac{\text{TempGain}}{100} * (\text{ccdtemp_in_Kelvin} - \text{TempOffset})$$

The TempGain and TempOffset constants are CCD package and camera specific, they are calibrated for each camera. A temperature sensor inside the TEC package converts temperature to current. The current passes through a resistor and the voltage on the resistor (representing CCD temperature) is displayed by a Voltmeter LCD display. Temperature can be set in PixelView in **Control, Camera Setup...** (Ctrl-C), by using the CCD temperature slider in the CCD tab within the “Camera Setup” dialog box.

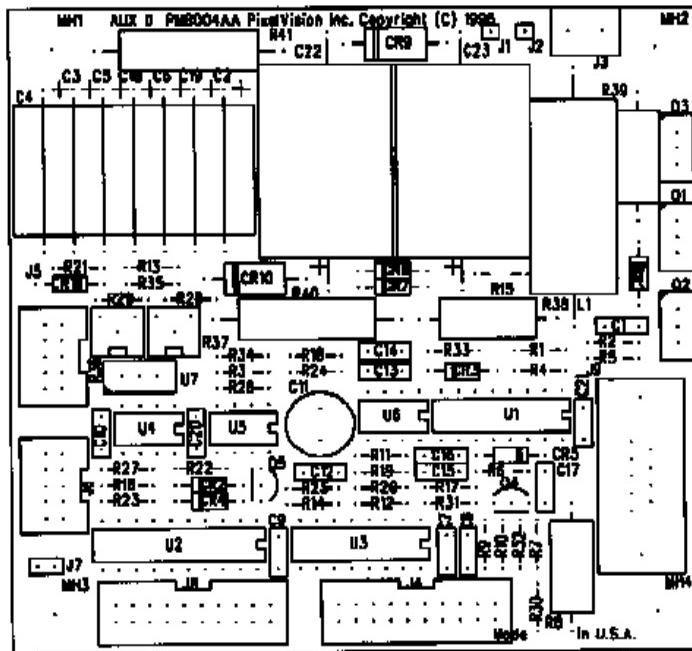


Figure 9 SpectraVideo Shutter and Cooler Control Board Layout

9. DATA ACQUISITION BOARDS

9.1. LYNXPCI DATA ACQUISITION BOARD

The LynxPCI data acquisition board can be used for 8-, 12-, and 16 bit input from scientific and non-standard digital cameras. With the serial input option, the board can accommodate the input simultaneously from up to four data streams.

9.1.1. FEATURES

- PCI bus data transfer rates greater than 80 Mbytes/second
- Single 16 bit parallel acquisition or up to four 16 bit serial fiber optic channels
- Master Mode PCI Plug-and-Play compatible
- Fiber optic serial input option available to reduce environmental corruption of data
- Software drivers available for Microsoft Windows 95, Windows NT, or Windows 3.1
- Uses system memory
- Fiber optic transmission option allows cameras to be “remoted” up to two kilometers away

9.1.2. GENERAL DESCRIPTION

Specifically designed for use with digital camera systems, the LynxPCI data acquisition board captures and stores the parallel or serial data from digital cameras to system memory.

The LynxPCI can accommodate up to four digital serial data streams, and when implemented with other LynxPCI boards, can accommodate an unlimited number of serial inputs. ‘Plug-and-Play’ PCI operation allows users to easily add LynxPCI boards to expand the number of captured channels. No special configuration file is required. This makes it ideal for multiple camera head systems or for camera systems that have multiple output data streams. By using fiber optic serial cables, the LynxPCI overcomes the limitation of SCSI type data transmissions, and allows operation of your camera up to 2 kilometers from the host computer system.

LynxPCI’s specially designed line buffering architecture eliminates the need for costly full frame memory and reduces system complexity and size.

9.1.3. ARCHITECTURE

The LynxPCI data acquisition board is a PCI-compliant card providing a parallel or serial interface to digital cameras from PixelVision and other manufacturers. A serial wire interface can be used for short distance transfers. A fiber optic cable option is available for long distance data transfer and high data integrity.

Taking advantage of the PCI Bus speed in DMA master mode, the LynxPCI can transfer to host RAM an unlimited number of consecutive frames across the bus in real time. Because system resources are not involved in transferring data, the computer's CPU is free to perform other tasks such as image processing or network transfers of the acquired data.

Unlike other popular data acquisition boards that use costly full frame memory to buffer images, LynxPCI uses doubled FIFO or dual-port memory buffers. LynxPCI writes incoming data into one memory buffer while another is read by the PCI controller – guaranteeing uninterrupted data acquisition. The LynxPCI is a very versatile data acquisition board that uses the Taxi™ serial transmission standard. The LynxPCI can be configured to receive data in parallel single ended or parallel mode. It can also receive multiplexed data over a serial data cable that can then be de-multiplexed on the LynxPCI board so that the image is correctly placed into memory.

Table 11 shows the different data acquisition configurations for the data acquisition board.

Mode	Configurations	LynxPCI Channel			
		0	1	2	3
1	Parallel Acquisition	✓			
2	Serial Acquisition, 1 channel	✓			
3	Serial Acquisition, 2 channels de-multiplexed from a single multiplexed data stream	✓	✓		
4	Serial Acquisition, 4 channels de-multiplexed from a single multiplexed data stream	✓	✓	✓	✓
5	Serial Acquisition, 2 individual channels	✓	✓		
6	Serial Acquisition, 4 individual channels	✓	✓	✓	✓

Table 11 LynxPCI Permissible Configurations

9.1.4. GENERAL SPECIFICATIONS

LynxPCI Data Acquisition Board	
DIGITAL INPUTS	16 bit parallel, 15 MHz Pixel Clock 16 bit serial, 4 MHz Pixel Clock
SYNCHRONIZATION SIGNALS	Frame Blank, Line Blank, Data Valid
DIGITAL OUTPUTS	"Taxi" Serial 4 bit
CONTROL INTERFACE	8 bit I/O Mapped
ON BOARD MEMORY	Each Line: up to Four 16 bit FIFOs (1KB or 4KB)
PCI INTERFACE	32 bit Master Mode, 32 bit Memory Map
POWER	+5VDC, 3A (max)
MTBF	30,000 hrs.
OPERATING TEMPERATURE	0 – 70 Degrees Celsius (non-condensing)
STORAGE TEMPERATURE	-20 to 85 Degrees Celsius

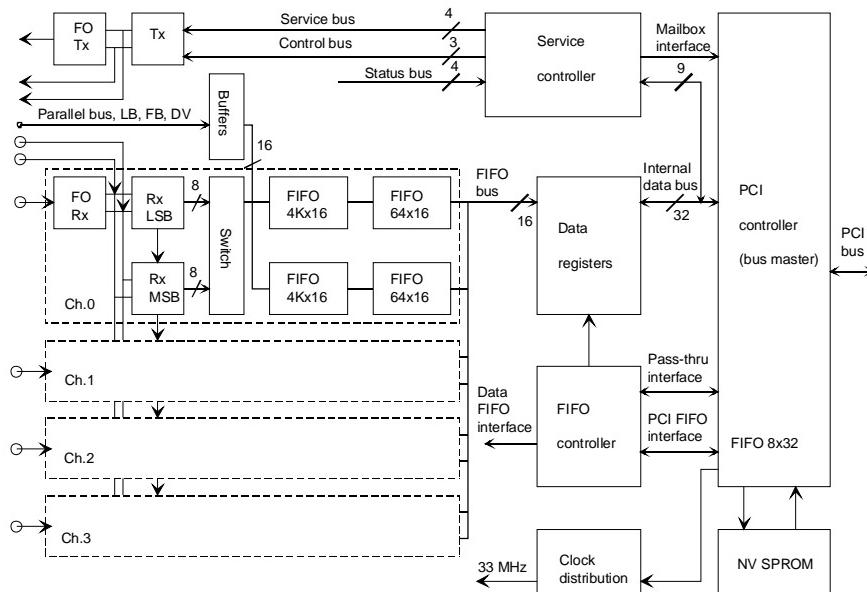


Figure 10 LynxPCI Data Acquisition Board PMB-002 Functional Diagram

10. BOARD TO BOARD ELECTRICAL CONNECTIONS

The SpectraVideo camera comes with the head assembly connected to the camera control box via an umbilical that should not be removed.

If individual boards are purchased, they need to be assembled with the socket board that holds the CCD.

The digital control board, analog signal processing board, and the CCD socket boards are connected as shown in Table 12.

Digital Control Board	to	Analog Signal Processing Board	
J3		J1	pin 1 to pin 1

Digital Control Board	to	Socket Board	
J6		J1 & J2	
J6 pin 1		J1 pin 1	

Table 12 Board to Board Connections

Depending on the individual CCD shipped with the socket board, analog signal processing board may be connected to either one of two sets of connectors. The data sheet will specify which connectors to use.

Analog Signal Processing Board	to	Socket Board	OR	To	Socket Board
J5		J3 & J4			J5 & J6
J5 pin 1		J3 pin 1			J6 pin 1

Table 13 PMB-003 to Socket Board Connections

11. SOFTWARE DEVELOPMENT

11.1. SPECTRAVIDEO SERIAL PORT INTERFACE

The SpectraVideo camera uses a serial interface to control some of the operation modes and timing parameters involved in image acquisition. A digital signal processor (DSP) which incorporates a serial port controls timing in the camera. Mode control and internal counters are set through this port. Serial communications to the SpectraVideo camera, which uses the PCI data acquisition board without the fiber optic link, is through the PC's RS-232 (COM) port. The port must be set up to use 9600 baud, 1 stop bit, 8 data bits and no parity. This section of the manual covers serial communication to those cameras that do not use the serial interface board and fiber optic link to the PCI data acquisition board. Additional commands are required for the serial interface board / fiber optic link.

Comm settings:	9600 Baud	1 stop bit	8 data bits	No parity
-----------------------	-----------	------------	-------------	-----------

There are two types of commands: reboot commands and data commands. Reboot commands consist of a single character (byte). Data commands are three characters sent without pause between them; first is the control character to tell the DSP which function is being accessed, and the second two are combined to form an integer. The port can be tested by sending single characters using a simple terminal emulator program, but typically these simple programs do not send characters quickly enough in succession to be able to address any of the data commands. Data command interpretation in the DSP is timed to look for the second and third bytes at a particular rate and if no data is present it will read the hexadecimal numbers 0xFF, 0xFF and interpret them as the hexadecimal integer 0xFFFF.

Data command syntax:	Control character	Data high byte	Data low byte
-----------------------------	-------------------	----------------	---------------

After every three-character command sequence, the DSP will respond over the serial port by sending back the three characters it received. If the control character is not recognized, it will also send back the ASCII character '?'. This feature is useful for determining whether the DSP is responding to serial port commands. With fiber optic links, an ACK is not returned if an invalid command sequence is sent.

There is an eight-page PROM in the camera that contains the DSP code. The DSP is booted from PROM page 0 on power-up. Although the same basic DSP code is used in all eight PROM pages, the actual timing sequences in each page differs to accommodate the different clock timing patterns required for different CCD

outputs. Depending on the CCD output used in a particular camera and the analog gain state desired, the DSP may have to be rebooted after power-up but before doing anything else. The PROM pages to be used with a particular camera are highlighted in bold on the camera data sheet sent with the hardware.

All data commands must be in the range 0 to 16383 due to counter size limitations in the DSP except as noted. Some values will cause loops to be very long. Rebooting the camera from the power switch will clear this condition.

The DSP runs off a master clock and all timing is in units of master clock periods, referred to below as CLK. The actual clock period of a particular camera may be found on the data sheet and in the registry or pixview.ini shipped with the camera.

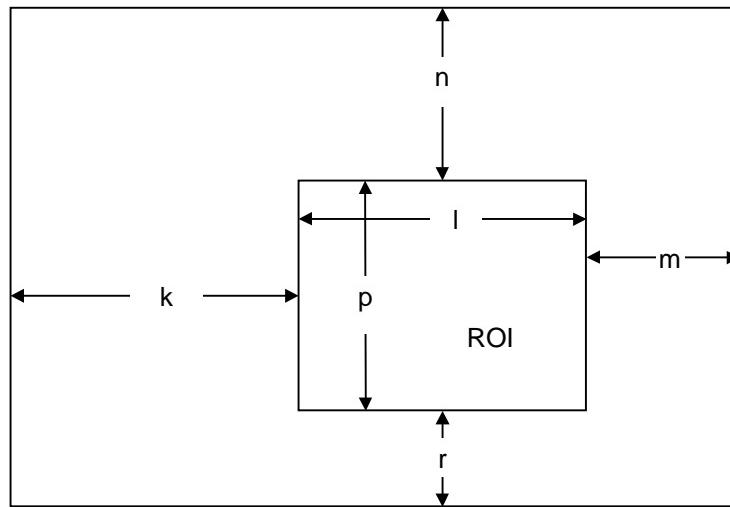
11.1.1. REBOOT COMMANDS

Control Character (ASCII)	Function	Discussion
0 to 7	Prom Page Reboot	Reboots the DSP from the selected PROM page. The pages for use with a particular camera are noted on the camera data sheet in bold.

11.1.2. REGION OF INTEREST (ROI) IMPLEMENTATION

The SpectraVideo camera supports Region-of-Interest (ROI) readout of the CCD. Both single ROI and multiple ROIs up to a maximum of 16 are supported. The ROI parameters are set through the serial port interface. The order in which the parameters are sent is important, depending on whether no ROI, single ROI or multiple ROI is desired—this order is elaborated below.

Single ROIs may be anywhere on the CCD, up to the edge of the device. Figure 11 shows the parameter names schematically for single ROI readout.



n = Lines before ROI

k = Pixels before ROI

r = Lines after ROI

m = Pixels after ROI

l = Width of ROI

p = Height of ROI

Figure 11 Single ROI Parameters

11.1.3. COMMAND SUMMARY

Control Character (ASCII)	Function	Discussion
a	Pixels per line	Sets the number of pixels per line in the digitized frame when ROI is disabled. This number must be greater than the number of serial shifts needed to fully clear the CCD serial register plus four to accommodate pipeline delays in the analog to digital conversion. It must be large enough to clear the lead-in pixels in the imager as well as the active pixels. If serial binning is used, this number may be divided by the number of serial pixels binned, but the extra 4 pixels for pipeline delay must still be added. Min = 1.
b	Lines per frame	Sets the number of lines in the digitized frame (minus one) when ROI is disabled. This number must be large enough to clear the entire active area of the CCD plus one to clock the last line into the PCI data acquisition board. If parallel binning is used, this number may be divided by the number of lines binned, but one must be added to clock the last line in. Min = 1.
c	Serial pixels binned minus 1.	Sets the number of serial pixels that are binned into summing well. Setting this number to 0 turns off serial binning; setting it to 1 bins two serial pixels, etc. Min = 0.

Control Character (ASCII)	Function	Discussion
d	Lines binned times num Y states	This number divided by eight sets the number of lines binned into the CCD's serial register. This number must be a multiple of num Y states. This command is for use with ROI disabled or single ROI. Min = 1.
e	Serial wait count	Sets the period of the unbinned serial readout pixel to: $CLK^2 * \text{base NumSerialState} + 3 * \text{SerialWaitCount}$ Min = 1.
f	Parallel wait count	Set the parallel state time (there are num Y states per parallel shift). Sets the parallel state time to $(5+\text{ParallelWaitCount}) * CLK$. The parallel gate drivers typically do not support state times shorter than 15 μ s. Min = 1.
g	Disking wait count	This wait occurs after parallel shift but before serial shift. It serves to extend the period between lines. Time waited is in units of unbinned serial pixel periods. Min = 1.
h	After exposure count	This wait occurs after exposure but before readout, in effect, extending the integration time after the TTL 'sync' output on the camera has gone high to allow time for the shutter to close, or phosphor to decay, etc. The serial register of the CCD is kept flushed during this period. The wait time is set to AfterExposureWait squared, times the unbinned serial pixel period. Min = 1.
i	ROI enable	Setting this to one enables single region of interest clocking (ROI), setting it to 0 disables it and sets the readout mode back to full frame. Setting it to a number greater than one enables multiple ROI readout, where the number designates the number of regions. Min = 1.
j	Serial flush wait count	Sets the serial pixel period for serial shifts used to flush the CCD (not during readout). Sets the period of the unbinned serial flush pixel to $(CLK^2 * \text{base Num Serial states} + 3 * \text{SerialFlushWaitCount})$. Min = 1.
k	Serial pixels before ROI	Sets the number of unbinned serial pixels to clear every line before the ROI.
l	ROI pixels per line	Sets the number of digitized pixels per line in the ROI. Serial binning parameters are used. Min = 1.
m	Serial pixels after ROI	Sets the number of unbinned serial pixels to clear after the ROI. This number should be high enough to clear the entire serial register.
n	Lines before ROI	Sets the number of imager lines to skip before reading out the ROI.
p	ROI lines	Sets the number of digitized lines in the ROI for single ROI readout only. Parallel binning parameters are used. Min = 1.

Control Character (ASCII)	Function	Discussion
r	Lines after ROI	Sets the number of imager lines to clear after reading out the ROI. For use with single ROI only.
s	Exposure timer mode	When set to 1, internal timing is used for exposure, when set to 0, exposure time is set by the low portion of exposure gate. When internal timing is used, exposure start is synchronized to the beginning of a serial shift.
t	Internal timer inner loop counter	Counter for internal exposure time loop. Exposure time equals (ReadoutSerialPixelPeriod*InnerLoopCounter*MiddleLoopCounter*OuterLoopCounter). Minimum InnerLoopCounter = 1.
v	Internal timer middle loop counter	See discussion for t above. Minimum MiddleLoopCounter = 1
w	Internal timer outer loop counter.	See discussion for t above. Minimum OuterLoopCounter = 1
x	CCD Temperature	See discussion in the Shutter and Cooler control board section
A	Reset multi ROI pointer	Resets the multiple ROI pointer (internal to the DSP) in order to begin loading multiple ROI parameters.
B	Enter multi ROI parameter	Enters the next multiple ROI parameter. The parameters are entered in order: 1) ROI lines in first ROI 2) Lines binned in first ROI * num Y states 3) Lines skipped to next ROI 4) Lines binned in lines skipped above * num Y states ... n) ROI lines in last ROI n+1) Lines binned in last ROI * num Y states n+2) Lines skipped to finish clearing CCD n+3) Lines binned in the last lines skipped * num Y states
D	Lines binned times num Y states before multiple ROI	Same as d except it only sets the binning of the lines before the first region of interest in multiple ROI readout.

12. SUPPORTING SOFTWARE

12.1. COMMTEST™ SOFTWARE USER'S GUIDE

CommTest is a program used to exercise the serial port of the Imaging Module. The Imaging module expects 9600 baud, 1 start bit, 8 data bits (lsb first), 1 stop bit, and no parity bit. This program is written to use Serial Port 2; Port 1 can be used by invoking Commtest /p1 on the run option command line.

Applicable files are:

commtest.exe

bwcc.dll

Commands for the Imaging Module are entered in the space beside the button Send. The format is:

char[hh][hh]CR

where:

char is the single ASCII character detailed in the Imaging Module manual for the particular command.

h is a hexadecimal character from 0 to f and the 2 characters must be inside brackets as shown.

CR is a carriage return.

The Clear button clears the response space in the window.

The Send button works the same as a carriage return if the Send button is highlighted.

The RS232 lines are optically isolated on the analog board before being fed to the DSP on the digital board. For the RS232 opto-isolators to function, the data cable of the I/O board must be connected to the data connector on the analog board. This I/O card provides +5V GND to the PC side of the optical isolators on the analog board. Plus five volts and GND must be supplied to the analog board data connector if an alternative I/O card is used.

The RS232 serial port connector is detailed in the Imaging Module manual.

The Imaging module will reply by echoing the characters sent to it. If it does not recognize a character it will return a '?'. A 'u' or 'U' alone is a useful command to find if the RS232 serial port is active since these are non-commands to the Imaging Module.



NOTE: The Imaging Module only accepts commands sent during flush mode, which, its normal idle state.

The imaging module expects all three 8 bit characters as above. If only the first is sent, the Imaging Module will fill in ff ff for the missing characters. If the Imaging module needs only a single character, as in the case of rebooting to a prom page, only one character needs to be sent.

12.2. PixLoad™ SERIAL PORT CONTROL SOFTWARE

The **PixLoad** software is a DOS executable program used to write serial port command sequences to the SpectraVideo camera. It is copied to the PixView directory during software installation. This program allows a series of commands to be written to the camera from a text file and checks for errors in the response.

12.2.1. TEXT FILE FORMAT

PixLoad reads a text file and sends the commands in the text file to the SpectraVideo camera over an RS232 serial port. Commands are sent to the camera at the DOS command line by typing the text file name as a command line argument to **PixLoad**. An example would be:

```
PIXLOAD file.clk
```

Where ‘file.clk’ is a file containing the alphabetic commands and their numeric values. A sample text file is included. The text file name must conform to the DOS filename format. The text file format must conform to the rules described in this section for the DSP commands to be sent appropriately. PixLoad depends on the text file to be left justified with ‘=’ signs separating the command character and the decimal data. **PixLoad** reinterprets the decimal data to hexadecimal format.

It is recommended that every command character in each line of ‘file.clk’ should be completed so that the camera is completely configured with a full command set each time **PixLoad** is invoked. Some of the values may be “don’t-cares” in some modes of clocking operation. In this case, a value of 1 or 0 is sufficient as the numeric value.

The text file may have any number of lines. The first line of the file **must** be present to select the PC Serial Port to be used. The first line must say:

```
port=x
```

where x is the number of the serial port being used.

Additional lines are text characters of the form ‘char=number’. The number is in decimal integer format. A DSP command character must be the first character in the line. The next character must be an ‘=’ sign with the data number immediately following with no spaces. Comments may also be added to the end of a command by placing an apostrophe at least two spaces away from the command string. All text after the apostrophe is considered a comment. Comments are allowed

between command lines only if the first character is left justified and is an apostrophe (‘).

Imaging Module PROM pages are accessed by loading different ‘file.clk’ which have a numeric first character rather than an alphabetic command character. The PROM pages control the direction of CCD clocking and hence, are designed specifically for selecting individual amplifiers unique to each SpectraVideo system. PROM pages are also used to select the gain characteristics of the correlated double sample analog signal chain on the analog board. High gain and low gain for each of 4 outputs are generally programmed in the DSP PROM. Consult the Data Sheet received with the SpectraVideo camera for choice of PROM page numbers (0 through 7).

The **PixLoad** program converts the decimal value to a hexadecimal format used by the DSP. See Section 11.1 on the SpectraVideo serial port interface for details on the serial port command syntax.

12.2.2. SAMPLE TEXT FILE

The following is a sample listing of the ‘file.clk’ contents with typical values:

```
port=2    ' MUST be on first line, left justified
'pc serial port, 9600 baud, 1 start, 1 stop bit, no parity, 8 data bits, set internally.
' must be first line of text file.
'
' Next is the commands,
' The first character is the prom page from which to boot, the numbers after the = are
' don't cares but necessary.
0=00          ' prom page for gain and amplifier selection
'               next is pixels per line
a=1044        ' pixels per line = lead in pixels + central array pixels + 2
'
b=1024        ' lines per frame = central array rows
c=0           ' serial pixels binned minus 1, pixels group size = c+1.
d=8           ' parallel states used per parallel shift, rows binned = d/8.
e=32           ' serial wait count, pixel period = (19+e*3)*100ns. (10mhz DSP
               clocks)
f=150          ' parallel wait count, wait = f*100ns.
g=600          ' discing wait count, wait = g*pixel period.
h=200          ' after exposure wait count, h*h*pixel period.
```

```

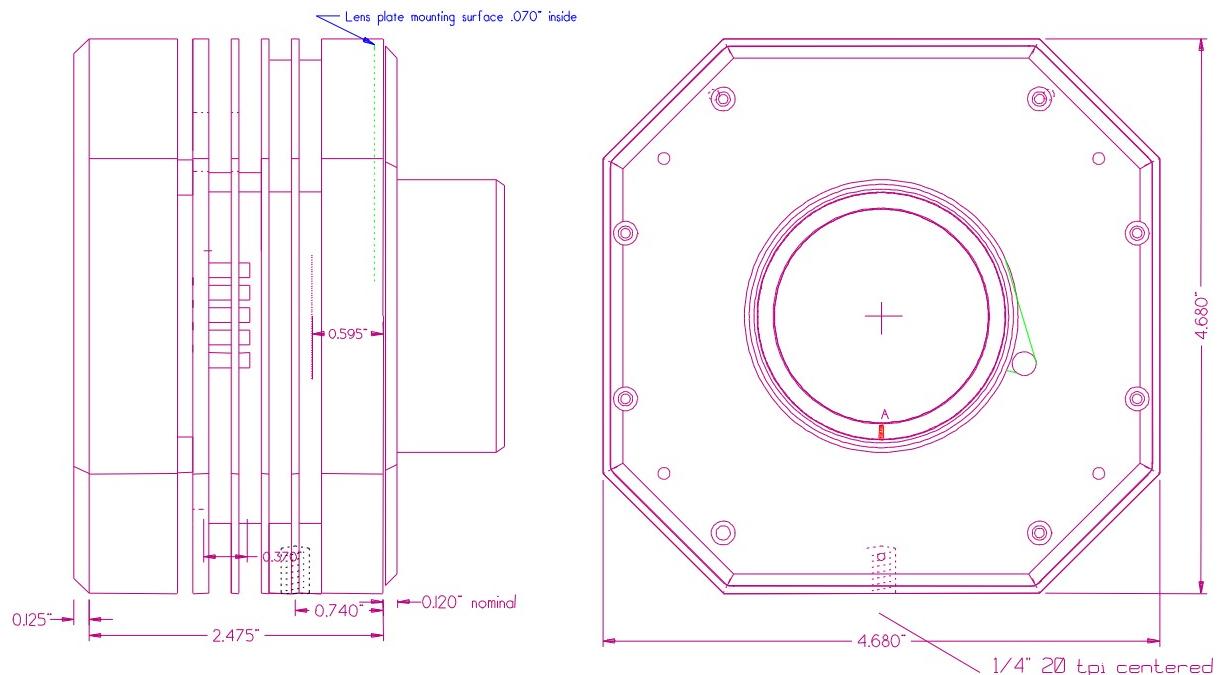
i=0          ' (1) region of interest mode switch, (0) no roi.
j=15         ' serial flush wait count = j*pixel period.
k=18         ' pixels skipped before region of interest.
l=1024        ' unblanked pixels in region of interest.
m=0          ' pixels skipped after region of interest.
n=0          ' lines skipped before region of interest.
p=1024        ' unblanked lines in region of interest.
r=0          ' lines skipped after region of interest.
s=0          ' (1) internal/ (0) external exposure control.
t=1000        ' internal exposure counter, inner loop.
v=1          ' internal exposure counter, middle loop.
w=1          ' internal exposure counter, outer loop.
'           exposure period = W*(V*(T*pixel period)+0.3μs)+0.3μs+0.4μs
x=48128      ' TE cooler controller command word. 8 bits used in MSByte (256
'           to 65535 modulo 256)
'           only the MSByte is sent to the TE cooler controller hence the modulo function -
'           example given is
'           [78][BC][00] hexadecimal bytes or x[BC][00]

```

13. APPENDICES

13.1. APPENDIX A

13.1.1. HEAD ASSEMBLY MECHANICAL DRAWING

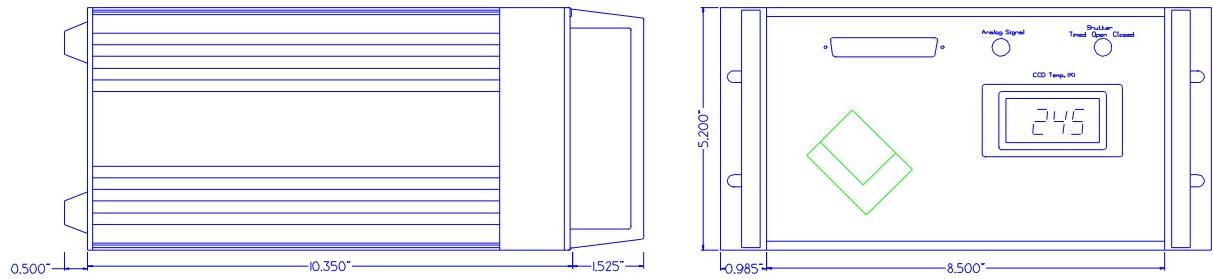


Head Assembly Mechanical Specifications:

Weight: 2.5 lbs.

13.2. APPENDIX B

13.2.1. CAMERA CONTROL BOX MECHANICAL DRAWING



Camera Control Box Mechanical Specifications:

Weight: 7.0 lbs.

13.3. APPENDIX C

13.3.1. SPECTRA VIDEO 1 CAMERA LOW LEVEL COMMAND SUMMARY

Command Name	SpectraVideo 1 Camera Control commands
port=2	This command is used with pixload.exe. Other programs specify the serial port in their own ways. pc serial port, using 9600 baud, 1 start, 1 stop, no parity, and 8 data bits. Only parallel output cameras use the PC's serial port. Cameras using serial PCI I/O boards use the serial control port on the PCI I/O board.
	The SpectraVideo camera stays in flush mode until it receives an exposure trigger. The camera then enters the exposure mode. At the end of the exposure period, the camera enters the readout mode. At the end of readout, the camera returns to flush mode. The camera ignores the serial control port except when in flush mode.
	The first camera control character is the prom page from which to boot, the numbers after the '=' are don't cares but necessary.
	This file requires the user/host to do some calculations based on constants associated with the camera. These constants are in pixview.ini or are listed on a separate data sheet sent with the camera.
	prom page, used to configure the camera characteristics, CCD output, analog gain or bandwidth, custom characteristics.
	X size of CCD, serial pixels per row. At least this number of serial pixels plus lead-in and lead-out pixels + 2 must be shifted out of the CCD on each row.
	Y size of CCD, number of CCD rows. At least this number of rows must be shifted out of the CCD for each frame.
	Typical values X size Y size
	SI502 3+15+512 512
	SI003 3+15+1024+15 1024
	1100*165 3+15+1100+15 165
	masterClock, 100ns or 62.5ns, this is the master oscillator in the camera
	baseNumSerialStates, i.e. 19, used with 'e' and 'j' to calculate pixel period.
	pixel period is a parameter of the camera to support the analog board CDS circuit.
	numYStates, i.e. 6, the number of parallel shift states per row. parallel states = CCD rows to be binned to one group * numYStates CCD rows = binned row groups * rows per frame parallel shift state period, A minimum value set by the camera or by the CCD

Command Name	SpectraVideo 1 Camera Control commands
	row shift period = parallel shift state period * numYStates tempGain, a number used in CCD temperature calculation. tempOffset, a number used in CCD temperature calculation.
s=1	Timed internal exposure mode. Not needed at this point for SV 1 cameras.
U=5555	This command unlocks the control port and returns ACK. This command is always sent after the camera has booted such as at power up or a commanded boot as in the next command.
0=0000	Boot to this prom page (0 through 7)
s=0	External exposure. The camera waits in flush mode. Exposure starts on the falling edge of Expo In. Exposure ends on the rising edge of Exposure In.
s=1	Internally timed exposure. The camera waits in flush mode. Exposure starts on the falling edge of Exposure In. Exposure duration is calculated from pixel period and the values of t, v, and w.
s=2	Video mode is not supported.
x=47995	digital value for CCD temperature control. $x = 256 * \text{tempGain} / 100 * (\text{CCD temperature in Kelvin} - \text{tempOffset})$
i=0	Region of Interest mode switch, (0) no region of interest (roi), (1) 1 roi (n) n ROIs with n rods see discussion at 'B'.
a=number	pixels per row (line) = lead in pixels + central array pixels + 2. This is the number of pixels per row (line) in the image when i = 0.
b=number	rows (lines) per frame, i must be set first. When i=0 or 1, b is the number of rows in the readout frame. When i>1, b is ignored.
z=3	warm-up pixels shifted out before 'a' pixels (default = 3). These pixels fill the pipe line in ADC and are binned as readout pixels. ROD pixels are not reduced.
E=1537	Not used as CCD's have full frame readout
F=64	Not Used
n=0	lines skipped before region of interest, requires i > 0 to activate.
p=number	number of lines in single region of interest. i must be set to 1 before entering p or r commands, otherwise they will be ignored. p and r are retained for backward compatibility and for simplicity. When using p and r commands the r command must immediately follow p.
r=number	number of lines in region of disinterest following the single region of interest set by p. i must be set to 1 first.
d=6	parallel states in flush mode and if i=0 it is also used for readout. rows binned = d / numYStates.
D=6	parallel states used per row shift in rod before first roi, requires i > 0 to activate. rows binned = D / numYStates.

Command Name	SpectraVideo 1 Camera Control commands
A=00	sets a pointer to a data structure. Must appear immediately before group of 'B' statements.
B=165	Use of B is safer than use of b, p, r since the camera must store b, p, r into the structure used for B. if i = 0, this is rows (lines) per frame. if i > 0, B = lines in first roi.
B=6	the number of parallel states associated with B above. rows binned = B / numYStates. CCD rows = binned rows * rows per frame
B=0	if i = 0, this is not used. if i > 0, B = lines in first rod. This B may equal 0.
B=6	the number of parallel states associated with B above. rows binned = B / numYStates. CCD rows = binned rows * rows per frame
	Add a group of 4 Bs for each additional roi greater than 1 (i=n). The sum of all roi rows (lines) = number of lines in the image
c=0	serial pixels binned minus 1, pixels group size = c + 1.
e=20	serial wait count, pixel period = (baseNumSerialStates + e * 3) * masterClock. Some proms have fixed serial timing
f=60	parallel wait count, parallel shift state period = (f-4) * masterClock .
h=1	after exposure wait count = h * h * pixel period.
j=20	serial flush wait count, pixel period = (baseNumSerialStates + e * 3) * masterClock.
k=14	pixels skipped before region of interest, requires i > 0 to activate.
l=1100	pixels in region of interest, requires i > 0 to activate. This is the number of pixels per row (line) in the image
m=16	pixels skipped after region of interest, requires i > 0 to activate.
t=10204	internal exposure counter, inner loop. t should be maximized with v and w minimized for best time linearity. Each value t, v, w, must be less than 16383.
v=2	internal exposure counter, middle loop.
w=1	internal exposure counter, outer loop. exposure period = w * (v * (t * pixel period)))
G=number	Not used
H=number	Not used
N=number	Not used
s=number	Not used
I, J, K, L, M, O	These commands were used for the ADAPT™ camera and are unique to that camera.

13.3.2. DSP CONTROL OUTPUTS

SpectraVideo Camera Control commands	
Clamp Sample from DSP	
Shutter	Shutter open during Exposure period closed during readout. This signal is used as Shutter Sync Out
Frame Blanking	High for flush period and exposure period, low for readout.
Line Blanking	High for row shift period of each line. The PCI I/O board blanks the first LB pulse since data is not meaningful until after the first line is written to line buffer. An additional line must be read from CCD so that that line will be read from PCI I/O board line buffer to PC ram.
Data Valid	Rising edge pulse that latches data word to pixel or line buffer in I/O board.
Data Output Enable	In SpectraVideo cameras with multiple analog channels, a group of 4 pulses enable individual Pixel Data latches for transfer to the I/O board. This pulse is internal to the camera.

GLOSSARY OF ACRONYMS AND TERMS

Amplifier

The amplifier converts electronic charge to a voltage. It also provides gain sufficient to drive the signal off of the chip and to the analog signal processing electronics.

ADC

Analog-to-Digital Converter.

Back-illuminated CCD

Back-illuminated charge-coupled device. Light enters through the backside of the thinned CCD instead of passing through the polysilicon gate structure as in conventional front illumination. Back-illuminated CCDs are typically much more sensitive, especially at short wavelengths.

CCD

Charge-Coupled Device.

CDS

Correlated Double Sample. A technique of analog signal processing that eliminates the substantial contribution of "reset" noise to the readout noise of the CCD.

DSP

Digital Signal Processor. The integrated circuit used to generate the logic for the CCD clocking sequence.

Lead in pixels

Lead in pixels are extra pixels in the serial register between the imaging array and the output amplifier. These pixels are used to distance the amplifier from the imaging area.

Looping

Looping acquires images continuously and displays them in a single window. Commonly this mode is used for setup and focussing.

LUT

Lookup Table. The table used to convert digital pixel value to displayed grayscales or colors. For example, a standard gray scale LUT may convert the minimum pixel value to black, the maximum to white and those between to ascending shades of gray.

Overscan

Clocking (shifting) more pixels out of the CCD than are physically contained in the imager results in overscan pixels. Overscanning the serial register results in an image with extra columns while overscanning the parallel register results in extra rows. Overscan pixels provide a good measure of the offset.

Parallel Array

The main imaging area of the CCD is referred to as the parallel array. A “parallel row transfer” occurs when this array is clocked through one row sequence, because multiple charge packets are transferred in parallel.

PCI

Peripheral Communication Interface

PROM

Programmable Read Only Memory. The DSP program is loaded from PROM on power-up or on system reboot.

Quantum efficiency

Photon-to-electron conversion efficiency in the CCD.

ROA

Region Of Analysis.

ROI

Region Of Interest. Only those pixels in the ROI are digitized during CCD readout when ROI is enabled.

Serial register

The register along the side of the CCD’s imaging array that is used to transfer charge packets out serially, one pixel at a time.

Two-point correction

Pixel-by-pixel correction that removes dark current and optical field variations. The corrected pixel has a dark pixel subtracted and a flat field coefficient multiplied by the result.

Virtual memory

A memory swap space on fixed disk.

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